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Prognostic Value of the Computerized ECG in Hispanics‡

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Summary

Background: The prevalence and prognostic values of electrocardiogram (ECG) abnormalities in Hispanics have not been compared to other ethnicities in a large population. Despite a worse cardiovascular risk profile, the prevalence of cardiovascular disease is lower in Hispanics compared to non-Hispanics.

Hypothesis: We hypothesized that ECG abnormalities were less common in Hispanics and were not as strongly associated with cardiovascular mortality.

Methods: 45,563 ECGs ordered for usual clinical indications in a Veteran's hospital were available for analysis. 1,392 patients who died within one week of the ECG were excluded. Demographic characteristics were recorded and the population was followed for an average of 7.5 years using the California Death Index. The presence of baseline ECG characteristics were recorded and analyzed using the GE/Marquette computerized ECG system. Age, sex and heart rate adjusted Cox hazard ratio analyses were performed.

Results: Being Hispanic was associated with lower cardiovascular death, with a hazard ratio (HR) of 0.76 (95% CI 0.65–0.89). Findings such as atrial fibrillation, presence of Q-waves, left ventricular hypertrophy (LVH), upright T-waves in aortic valve replacement (aVR) and cardiac Infarction Injury Scores > 6 were significantly less prevalent in Hispanics than in non-Hispanics. These findings were similarly associated with increased cardiovascular mortality in both groups, each with a HR of approximately 2.

Conclusion: The lower prevalence of ECG characteristics associated with coronary heart disease, atrial fibrillation and left ventricular hypertrophy support prior observations that cardiovascular disease is less prevalent in the Hispanic population. These findings, however, are similarly associated with increased mortality compared to non-Hispanics.

Key words: hispanics, electrocardiogram, prognosis, atrial fibrillation, left ventricular hypertrophy, coronary heart disease

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Introduction

Although Hispanics have a worse cardiovascular risk factor profile than non-Hispanics, cardiovascular disease is less prevalent in Hispanic men than their non-Hispanic counterparts. The prevalence of diabetes,[1,2] insulin resistance,[3] obesity[1,4] and hypertriglyceridemia[2,5] as well as the overall Framingham risk scores[5] are higher in Hispanics than in non-Hispanics.

Initial observations paradoxically showed that the rate of death from cardiovascular disease in Hispanic men living in the southwestern United States was nearly a third lower than that of non-Hispanic men.[6] However, more recent reports have argued that this could be explained by under-ascertainment of deaths[7] and that when adjusted for confounders, the rates of deaths were likely equal or in certain subgroups potentially higher.[8]

This does not exclude, however, the possibility that the incidence or prevalence of cardiovascular disease

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in Hispanics is lower. The San Antonio Heart Study suggested that Hispanics have a lower incidence of myocardial infarction.[9] Lower coronary calcium scores have also provided indirect evidence that the prevalence of coronary artery disease (CAD) is lower in Hispanics.[10]

Studies reporting differences in ECG findings between Hispanics and non-Hispanics are scarce and small in scale. One study reported that the frequency of repolarization abnormalities was lower in Hispanics than in non-Hispanics.[11] Since ECG abnormalities reflect underlying cardiac pathology, documentation of differences in these findings should help support whether Hispanics have a lower prevalence of cardiovascular disease or otherwise. Furthermore, the prognostic value of ECG abnormalities in Hispanics has not been studied in a large population.

The purpose of this study was to establish the prevalence of ECG abnormalities in a large Veteran Hispanic population, to identify the association between these findings and cardiovascular mortality and to compare these findings to those of a similar, non-Hispanic population.

Methods

Study Design: The Palo Alto Veterans Affairs (PAVA) Health Care System uses a computerized ECG system (GE Marquette) to collect, store and analyze ECGs. This system has been validated by both the United States Food and Drug Administration and the European Community and is widely used across the world. The current study involved a retrospective analysis of 45,563 ECGs obtained between March 1987 and July 2000 that were ordered for usual clinical indications. In cases where more than one ECG was available for a patient, only the first ECG was considered. The race, age, gender, weight and height of each patient were recorded. Race classification was based on self-proclamation at the time of registration.

Exclusion Criteria

At the outset, 1,060 patients who died within 1 week of their ECG being recorded were excluded since the ECG could be directly associated with the death rather than being predictive of death. Patients with paced rhythms ($n = 290$) and Wolff Parkinson White syndrome ($n = 42$) were also excluded from the study, leaving 2,625 Hispanics and 41,546 non-Hispanics with ECGs for comparison.

ECG Analysis

The recorded data on each ECG included the timing and voltages at each of the points of the PQRST complex of the basic eight leads with derivation of the remaining four leads. The system was also able to flag rhythm abnormalities, measure standard intervals and perform waveform analysis to provide the basic electrocardiographic interpretations (GE 12 SL analysis program, www.gesystems.com). Standardized computerized ECG criteria as described by the GE 12-lead electrographic analysis program were used for the diagnosis of Q-waves, ST changes, and bundle branch blocks. From these measurements, the Romhilt-Estes criteria for left ventricular hypertrophy (LVH),[12] QRST spatial angles,[13] Cardiac Infarction Injury Scores (CIIS)[14] and Selvester[15] scores were calculated.

Outcome Variables

The primary outcome variable in the study was cardiovascular (CV) mortality. The California Death Index (from the California Department of Health Services) and the Social Security Death Index were used to ascertain the vital status of each patient as of Dec 31, 2002.

Statistical Analysis

The Number Cruncher Statistical System (Kaysville, Utah) was used for analysis. The ECG database and death indices were merged using Microsoft Access (Redmond, WA). Bivariate associations between CV mortality and various ECG criteria were tested via Chi-squared tests (dichotomous variables) and Student t-tests (continuous variables). All variables were first tested for normality of distribution. P-values less than 0.05 were considered statistically significant. Cox proportional hazard testing was conducted to assess the significance and independence of variables for predicting CV mortality, and hazard ratios were calculated. The Cox models were age, sex and heart rate adjusted. Kaplan–Meier curves were generated to display the impact of Hispanic race and atrial fibrillation on survival.

Results

Baseline Demographics: The study subjects were followed for an average of 7.5 years. After excluding the 1,060 deaths that occurred within 1 week of the ECG recording, there were a total of 4,332 cardiovascular deaths. There were 165 (6.3%) Hispanics vs. 4,167 (10.0%) non-Hispanics who died from a cardiovascular cause ($p < 0.0001$).

Table 1 presents the baseline characteristics of the study population, comparing Hispanic and non-Hispanic patients. The mean age of the Hispanic cohort was 54, which was slightly lower than that of the non-Hispanic population at 57 ($p < 0.001$). There was a smaller percentage of women in the Hispanic cohort (8.8%) than the non-Hispanic cohort (10%, $p = 0.01$). The Hispanic population on average was more overweight with a mean Body Mass Index (BMI) of 28.4, vs. 27.2 in the non-Hispanic group ($p < 0.0001$).

TABLE 1 Baseline demographics and cardiovascular deaths of study population

Characteristic	Hispanic population (n = 2,625)	Non-hispanic population (n = 41,546)	P value
Age (yrs)	53.8 ± 13.8	56.9 ± 14.7	<0.001
Female	230 (8.8%)	4,240 (10%)	0.01
BMI	28.4 ± 5.3	27.2 ± 5.5	<0.0001
Heart rate (bpm)	72.1 ± 15	73.8 ± 16	<0.0001
Cardiovascular death	165 (6.3%)	4,167 (10.0%)	<0.0001

Values are mean ± standard deviation or number of subjects (percent).
Abbreviations: BMI = body mass index.

Electrocardiographic Characteristics

Several ECG abnormalities seen in Table 2, including atrial fibrillation, left atrial enlargement, right axis deviation (RAD), prolonged QTc, pathologic Q-waves, ST depression and LVH were significantly less prevalent in Hispanics compared to non-Hispanics. Of note, atrial fibrillation was less than half as prevalent in the Hispanic group as in the non-Hispanic group (1.2% vs. 2.8%, $p < 0.0001$). Using a Romhilt-Estes score of >3, LVH was found in 3.3% of Hispanics while 5.3% of non-Hispanics had this finding ($p < 0.0001$). Also of note, pathologic Q-Waves were found less frequently in the Hispanic cohort (10.6% vs. 12.3%, $p = 0.006$). Table 3 demonstrates differences in several advanced ECG characteristics between Hispanics and non-Hispanics. QRST spatial angle > 100 (8.6% vs. 10.7%, $p < 0.0001$), upright T-waves in aortic valve replacement aVR (7.3% vs. 9.7%, $p < 0.0001$), and a Cardiac Injury Infarction Score (CIIS) >30 (4.0% vs. 6.2%, $p < 0.0001$) were found less frequently in Hispanics.

The prevalence of atrial fibrillation, left bundle branch block (LBBB) and LVH were then plotted over progressive age brackets in both Hispanics and non-Hispanics (Figure 1). The trend for each of these findings was towards an increase in prevalence with increasing age in both groups. For any given age bracket, atrial fibrillation, LVH and LBBB were less prevalent in the Hispanic population compared to the non-Hispanics.

Cox Hazard Analysis

Adjusting for age, sex and heart rate in the proportional hazards models, several ECG findings were individually evaluated for associations with cardiovascular mortality (Table 4). Atrial fibrillation, left atrial enlargement, LBBB,interventricular conduction delay (IVCD), QTc prolongation, pathologic Q-waves, ST depression, LVH, QRST spatial angle > 100, upright T-waves in aVR, Cardiac Infarction Score (CIIS) > 30 and a Selvester Score > 6 were individually statistically significantly associated with an approximately two-fold increase in risk of cardiovascular mortality after adjustment for age, sex and heart rate in Hispanics. The degree of increased risk afforded by each of these findings was similar to that seen in the non-Hispanic population. Of interest, both atrial fibrillation and left atrial enlargement provided a higher hazard ratio (2.3, CI 1.1–4.8 and 2.4, CI 1.3–4.4, respectively) in the Hispanic group than the non-Hispanic group (1.6, CI 1.5–1.8 and 1.9, 1.7–2.1, respectively), although the confidence intervals between the two groups did overlap. On the other hand, LVH provided a slightly lower hazard ratio (1.9, CI 1.1–3.5) in the Hispanic group than the non-Hispanic group (2.5, CI 2.2–2.7), again with overlapping confidence intervals.

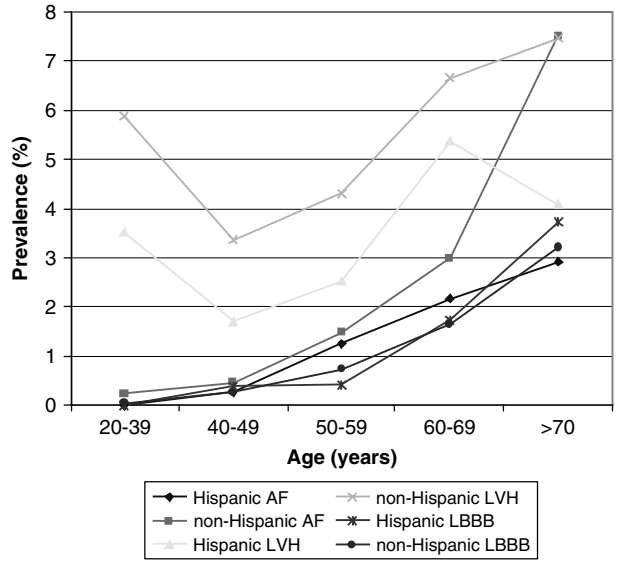

FIG. 1 Prevalence of Electrocardiographic characteristics in Hispanics and non-Hispanics by age distribution.

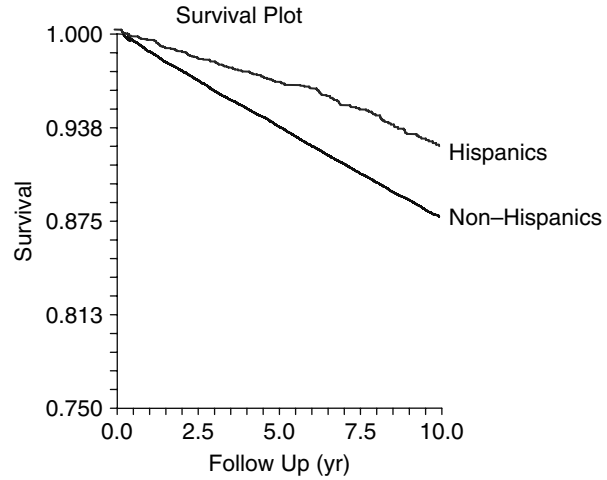

FIG. 2 Kaplan–Meier survival curve showing survival in Hispanics vs. non-Hispanics adjusted for age, sex and heart rate.

TABLE 2 Baseline electrocardiographic characteristics of study population

Characteristic	Hispanic population (n = 2,625)	Non-hispanic population (n = 41,546)	P value
Atrial fibrillation	32 (1.2%)	1,183 (2.8%)	<0.0001
Left atrial enlargement	61 (2.3%)	1,619 (3.9%)	<0.0001
Right axis deviation (RAD)	42 (1.6%)	983 (2.4%)	0.01
Left axis deviation (LAD)	245 (9.3%)	3,915 (9.4%)	0.87
Left bundle branch Block	29 (1.1%)	553 (1.3%)	0.32
Right bundle branch Block	93 (3.5%)	1,473 (3.5%)	0.99
QRS>110 ms	271 (10.3%)	4,760 (11.5%)	0.007
QTc>450	294 (11.2%)	5,799 (14.0%)	<0.0001
Pathologic Q-waves	277 (10.6%)	5,130 (12.3%)	0.006
ST depression[a]	184 (7.0%)	4,150 (10.0%)	<0.0001
Right ventricular hypertrophy	6 (0.2%)	121 (0.3%)	0.56

Values are number of subjects (percent).
[a] ST depression defined as more than 0.5 mm drop in ST segment in lead V5 from the isoelectric line.

Survival from Cardiovascular Death

Kaplan–Meier curves were plotted for survival from cardiovascular death in Hispanics vs. non-Hispanics. A significant separation of the plots was demonstrated (Figure 2). The annual mortality rate in the Hispanic group was 0.86% whereas the annual mortality in the non-Hispanic group was higher at 1.3% ($p < 0.0001$). Being Hispanic was protective of cardiovascular death with a HR of 0.76 (CI 0.67–0.89, p value < 0.001), adjusted for age, sex and heart rate.

Similar curves were plotted for Hispanic patients with atrial fibrillation vs. non-Hispanic patients with atrial fibrillation. A dramatic separation of the plots was demonstrated (Figure 3), although it must be noted that there were only 32 Hispanic patients with atrial fibrillation and 10 deaths in this group accounted for a precipitous drop in survival.

Discussion

Within a group of patients referred for ECG in a Veterans Hospital, we found that Hispanic patients had lower rates of cardiovascular mortality than non-Hispanics. Although similar observations about the rates of death from cardiovascular disease have been made in prior studies,[6] recent analyses suggest this may have been due to under-ascertainment of deaths in Hispanics[7] or failure to correct for confounding factors.[8]

This, however, does not discount the possibility that the *prevalence* of cardiovascular disease is lower in Hispanics. The lower incidence of myocardial infarction[9] and lower calcium scores[10] suggest this may be the case. Our findings that Hispanics have a lower prevalence of pathologic Q-waves as well as less ST depression and lower CIIS support this theory.

The paradox is that even though the rates of cardiovascular disease in Hispanics are lower, their risk factor profiles tend to be worse than those of their non-Hispanic counterparts.[1–5] The answers to this paradox lie in the environmental or genetic risk factors that have yet to be identified.

Identifying the differences in disease processes between races may provide clues to the underlying pathophysiology of these illnesses. The Veteran's Association

TABLE 3 Advanced electrocardiographic characteristics of study population

Characteristic	Hispanic population (n = 2,625)	Non-hispanic population (n = 41,546)	P value
LVH (Romhilt-Estes > 3)	87 (3.3%)	2200 (5.3%)	<0.0001
QRST spatial angle > 100	227 (8.6%)	4459 (10.7%)	<0.0001
T-wave upright in aVR	191 (7.3%)	4,043 (9.7%)	<0.0001
CIIS[a] > 30	105 (4.0%)	2,575 (6.2%)	<0.0001
Selvester Score > 6	213 (8.1%)	3,650(8.8%)	0.23

Values are number of subjects (percent).
[a] Cardiac infarction injury score.

TABLE 4 Cox proportional hazard analysis

Variable	Hispanics HR(95% CI)	P	Non-hispanics HR(95% CI)	P
Atrial fibrillation	2.3 (1.1–4.8)	0.01	1.6 (1.5—1.8)	0.0001
Left atrial enlargement	2.4 (1.3—4.4)	0.006	1.9 (1.7–2.2)	0.0001
Right axis deviation (RAD)	NS	NS	1.7 (1.4–2.1)	0.0001
Left axis deviation (LAD)	NS	NS	1.3 (1.2–1.5)	0.0001
Left bundle branch block	2.5 (1.1–5.3)	0.01	1.9 (1.7–2.3)	0.0001
Right bundle branch block	NS	NS	1.4 (1.3–1.6)	0.0001
QRS > 110 msec	1.7 (1.2–2.5)	0.005	2.1 (2.0—2.3)	0.0001
QTc > 450	2.1 (1.3–2.8)	0.001	1.8 (1.7–1.9)	0.0001
Pathologic Q-waves	2.1 (1.4–3.0)	0.001	1.9 (1.7–2.0)	0.0001
ST depression[a]	2.0 (1.3–3.0)	0.001	1.9 (1.7–2.0)	0.0001
Right ventricular hypertrophy	NS	NS	2.2 (1.5—3.4)	0.0001
Left ventricular hypertrophy[b]	1.9 (1.1–3.5)	0.03	2.3 (2.1–2.6)	0.0001
QRST spatial angle > 100	2.1 (1.47–3.19)	0.001	2.6 (2.38–2.79)	0.0001
T-wave upright in aVR	2.9 (2.0–4.3)	0.001	2.5 (2.5–2.8)	0.0001
CIIS[c] > 30	2.5 (1.6–4.0)	0.001	2.4 (2.2–2.6)	0.0001
Selvester score > 6	2.1 (1.4–3.1)	0.001	3.9 (1.9–2.2)	0.0001

Abbreviations: aVR = aortic valve replacement.
[a] ST depression defined as more than 0.5 mm drop in ST segment in lead V5 from the isoelectric line.
[b] Left Ventricular Hypertrophy Romhilt—Estes score > 3.
[c] Cardiac Infarction Injury Score.
Values represent hazard ratio (Confidence Interval).
NS = Nonsignificant.

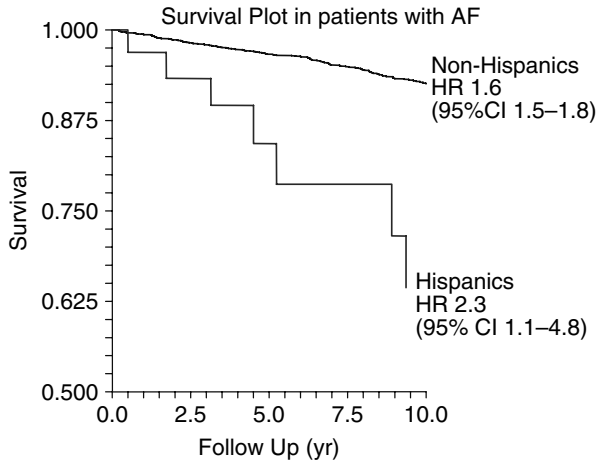

FIG. 3 Kaplan–Meier Survival curves showing survival in Hispanics with atrial fibrillation vs. non-Hispanics with atrial fibrillation, adjusted for age, sex and heart rate.

hospitals offer equal access to healthcare regardless of race or socioeconomic status[16] and provide a distinct advantage for studying race-based differences.

An extensive analysis of ECG characteristics as potential risk factors for cardiovascular disease revealed that several findings do confer a two-fold increase in risk for cardiovascular disease. However, this risk was not significantly different from that found in non-Hispanics. The answer to the Hispanic paradox, therefore, could not be found in the electrocardiogram.

One observation that merits further investigation is that atrial fibrillation was less than half as prevalent in Hispanics but conferred a particularly high hazard in the Hispanic group. To our knowledge, this difference has not been previously reported in such a large population.

There are a few limitations to our study that should be noted. Several clinical variables were not available, such as a more thorough risk factor profile, which could be potential confounders of our observed associations. In addition, the rates of ECG abnormalities reported reflect the prevalence of those referred for ECG testing which does not necessarily reflect that of the general population. In addition, it has been proposed that deaths in the Hispanic subgroups may be underestimated because they are more likely to return to their homeland when they are sick and closer to death. However, it may be argued that the Hispanics in the VA population, because of their access to good health care, are more likely to stay.

Conclusion

In summary, an analysis of over 44,000 ECGs revealed that the Hispanic subgroup had a lower rate of cardiovascular death, as well as a lower prevalence of several ECG abnormalities than the non-Hispanics. These ECG abnormalities each conferred an approximately two-fold increase in risk of cardiovascular death, which is similar to that of the non-Hispanic subgroup. Further studies are needed to find the risk factors that account for the lower

rates of cardiovascular disease in Hispanics compared to non-Hispanics.

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